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Soil moisture-atmosphere feedbacks mitigate declining water availability in drylands

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Global warming alters surface water availability (precipitation minus evapotranspiration, P-E) and hence freshwater resources. However, the influence of land-atmosphere feedbacks on future P-E changes and the underlying mechanisms remain unclear. Here we demonstrate that soil moisture (SM) strongly impacts future P-E changes, especially in drylands, by regulating evapotranspiration and atmospheric moisture inflow. Using modeling and empirical approaches, we find a consistent negative SM feedback on P-E, which may offset ~60% of the decline in dryland P-E otherwise expected in the absence of SM feedbacks. The negative feedback is not caused by atmospheric thermodynamic responses to declining SM, but rather reduced SM, in addition to limiting evapotranspiration, regulates atmospheric circulation and vertical ascent to enhance moisture transport into drylands. This SM effect is a large source of uncertainty in projected dryland P-E changes, underscoring the need to better constrain future SM changes and improve representation of SM-atmosphere processes in models.